

# **STATEMENT OF WORK FOR**

## **PLASMA AND SUPRATHERMAL ION COMPOSITION (PLASTIC) INVESTIGATION FOR STEREO PHASE B/C/D/E**

JULY 2001

STEREO PROJECT CODE 460  
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
GODDARD SPACE FLIGHT CENTER  
GREENBELT, MARYLAND

**CHANGE HISTORY LOG**

<b>Revision</b>	<b>Mod Number</b>	<b>Effective Date</b>	<b>Section</b>
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STATEMENT OF WORK FOR PLASTIC FOR STEREO PHASE B/C/D/E

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## TABLE OF CONTENTS

<u>1.0</u>	<u>INTRODUCTION</u> .....	1
<u>2.0</u>	<u>SCOPE OF WORK</u> .....	1
<u>3.0</u>	<u>APPLICABLE DOCUMENTS</u> .....	2
<u>4.0</u>	<u>REQUIREMENTS</u> .....	2
1000	<u>PROJECT MANAGEMENT</u> .....	2
2000	<u>SYSTEM ENGINEERING</u> .....	5
3000	<u>HARDWARE</u> .....	7
4000	<u>SOFTWARE</u> .....	9
5000	<u>GROUND SUPPORT EQUIPMENT (GSE)</u> .....	9
6000	<u>ASSEMBLY, INTEGRATION AND VERIFICATION (AIV)</u> .....	9
7000	<u>DATA PROCESSING</u> .....	10
8000	<u>SPECIAL TASKS</u> .....	10
9000	<u>SCIENCE</u> .....	10
10000	<u>MISSION OPERATIONS AND DATA ANALYSIS</u> .....	11

## **1.0 INTRODUCTION**

The primary goal of the Solar-Terrestrial Relations Observatory (STEREO) Mission is to advance the understanding of the three-dimensional structure of the Sun's corona, especially regarding the origin of coronal mass ejections (CME's), their evolution in the interplanetary medium, and the dynamic coupling between CME's and the Earth environment. CME's are highly energetic eruptions on the Sun, are the primary cause of major geomagnetic storms, and are believed to be responsible for the largest solar energetic particle events. CME's may also be a critical element in the operation of the solar dynamo because they appear to remove dynamo-generated magnetic flux from the Sun.

The STEREO Mission will accomplish this goal through the use of two spacecraft orbiting the Sun, one drifting ahead of the Earth and one behind. Simultaneous extreme ultra-violet (EUV) and visible image pairs along with simultaneous measurements of fields and particles will be obtained by STEREO at gradually increasing angular separations in the course of the mission. The STEREO spacecraft will be outfitted with two instrument suites and two instruments: the In-situ Measurements of Particles and CME Transients (IMPACT); the Sun-Earth Connection Coronal and Heliospheric Investigation (SECCHI); the Plasma and Suprathermal Ion Composition (PLASTIC); and STEREO/WAVES (SWAVES).

The Plasma and Suprathermal Ion Composition (PLASTIC) is one of four measurement packages on STEREO. PLASTIC will provide the plasma characteristics of protons, alpha particles, and heavy ions. This experiment will provide key diagnostic measurements in the form of mass and charge state composition of heavy ions and will characterize the CME plasma from ambient coronal plasma.

## **2.0 SCOPE OF WORK**

The objective of this work is the successful collection and analysis of simultaneous measurement of the plasma characteristics of protons, alpha particles, and heavy ions by the Earth leading and lagging STEREO spacecraft. This shall be accomplished through the design, fabrication, integration, calibration and testing of custom scientific instruments and their Ground Support Equipment (GSE); the design and development of flight, ground support and data analysis software for operating, retrieving and analyzing data from the scientific instruments for the lifecycle of the project; the formulation and documentation of plans and procedures to coordinate the activities of this experiment; and the publication of the scientific results obtained from this investigation. Once the flight instruments have been accepted by NASA and delivered to the mission integrator, the Johns Hopkins University Applied Physics Laboratory (JHU/APL), a period of Contractor support, as designated by the Contracting Officer's Technical Representative (COTR), shall follow for maintenance, repair and recalibration of the instruments and for

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**STATEMENT OF WORK FOR PLASTIC FOR STEREO PHASE B/C/D/E**

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technical support of the experiment, as well as for the reduction, analysis and interpretation of the science data and publication of scientific results.

JHU/APL, the mission integrator, and the contractor, shall work together in defining the interface between the instrument and the S/C. Together, they shall find solutions of instrument look angle interference, instrument accommodations, test and space environments that will be seen by both the instrument and the S/C and define the method of data transmission from S/C to ground. In order for both JHU/APL and the contractor to meet these responsibilities, JHU/APL and the contractor shall exchange information in the form of documents – all done with the knowledge and concurrence of the COTR.

### **3.0 APPLICABLE DOCUMENTS**

The following documents are applicable to the Statement of Work requirements and if any discrepancies, the SOW will take precedence.

- 1) *Stereo Mission Requirements Document* dated August 21, 2000 which can be found in the Centralized Configuration Management System which can be entered through Internet address: <http://gdms.gsfc.nasa.gov/gdms/plsql/frontdoor>
- 2) Phase A Concept Study (Technical Report) for the Plasma and Suprathermal Ion Composition (PLASTIC) (July 23, 1999)
- 3) *STEREO EMI/EMC Control Plan, JHU/APL 7381-9030*, DRAFT dated Feb 12, 01 (Final Version to be incorporated upon release)
- 4) *STEREO Contamination Control Plan, JHU/APL 7381-9040*, DRAFT, Revision a (Final Version to be incorporated upon release)
- 5) *STEREO Environments Definition, Observatory, Component and Instrument Test Requirements Document, JHU/APL 7381-9003*, DRAFT, Revision d (Final Version to be incorporated upon release)
- 6) *STEREO PLASTIC Interface Control Document, JHU/APL 7381-9014*, DRAFT, dated October 02, 2000 (Final Version to be incorporated upon release)

### **4.0 REQUIREMENTS**

The Contractor shall provide all labor, facilities, equipment, parts and supplies, except as otherwise provided herein, to complete and supply the following requirements.

#### **1000 PROJECT MANAGEMENT**

The Contractor shall technically and financially direct and administer the PLASTIC instrument.

- 1001 The Contractor shall report technical progress in weekly informal teleconferences with NASA and the spacecraft contractor.

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**STATEMENT OF WORK FOR PLASTIC FOR STEREO PHASE B/C/D/E**

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- 1002 The Contractor shall support STEREO programmatic, technical, and financial meetings and reviews. The Contractor shall coordinate its efforts with that of its subcontractors and the NASA. COTR.
- 1003 The Contractor shall implement a risk management program. The Contractor shall submit a Risk Management Plan for approval by the COTR in compliance with Section B2.
- 1004 The Contractor shall prepare and submit Monthly Technical Progress Reports. These reports shall begin following the Preliminary Design Review and shall be submitted in electronic format. These reports shall include the following topics:

Summary of Status - Summarize the current contract and schedule status. Identify any anticipated changes in schedule milestones.

Major Accomplishments - Summarize achieved accomplishments versus planned accomplishments for the previous month and delineate planned accomplishments for the next month.

Design Updates – Summarizing changes in resource requirements (mass, power and telemetry) and any major instruments specifications.

Outstanding Problems - State progress toward solving major problems previously identified; state whether action is required.

New Problems - Discuss major problems that have been identified during the past month; state whether action by GSFC is required. Identify potential work around positions if the problems will have a significant impact on the on-time completion of the contract or on critical scheduled milestones

Top 10 Risks – Identify the top ten risks items for the PLASTIC project. A mitigation plan and schedule shall be identified for each risk item.

Problem/Failure Quick Look – Provide a list of all open problem/failure reports and those problem/failure reports closed during the month. At a minimum, the list shall include an ID number for the problem, a description, an assignee, and the open/closed dates. This section of the technical report shall begin with the first application of power to the proto-flight and/or flight model for an electrical component (subsystem) or the first mechanical motion for a mechanical component (subsystem).

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**STATEMENT OF WORK FOR PLASTIC FOR STEREO PHASE B/C/D/E**

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- 1005 The Contractor shall conduct status meetings with the Government Representative informally at the Contractor's facility.
- 1006 The Contractor shall provide mass, power and telemetry resource budget updates. At a minimum the contractor shall report the mass, power, and telemetry resource allocations in written or electronic email form on a monthly basis. If a particular allocation has not changed, then a report of "no change" shall be provided.
- 1007 The Contractor shall participate in Peer Reviews of critical subsystems of the PLASTIC Instrument at a time and place as designated by the COTR.
- 1008 The Contractor shall prepare and submit a PLASTIC Preliminary Design Review (PDR) Data Package, which will be incorporated in the STEREO PDR data package.
- 1009 The Contractor shall present the PLASTIC PDR Data Package to the GSFC Code 301 Systems Review team in a location local to the GSFC area, in September 2001.
- 1010 The Contractor shall prepare and submit a PLASTIC Critical Design Review (CDR) Data Package which will be incorporated in the STEREO CDR data package.
- 1011 The Contractor shall present the PLASTIC CDR Data Package to the GSFC Code 301 Systems Review team in a location local to the GSFC area, in June 2002.
- 1012 The Contractor shall prepare and submit a PLASTIC Instrument (box level) Pre-Environmental Review (IPER) Data Package.
- 1013 The Contractor shall present the PLASTIC IPER to the GSFC Code 301 Systems Review team at a time and place designated by the COTR.
- 1014 The Contractor shall prepare and submit a PLASTIC Pre-Environmental Review (PER) Data Package which will be incorporated in the STEREO Observatory PER data package.
- 1015 The Contractor shall present the PLASTIC PER Data Package to the GSFC Code 301 Systems Review team in a location local to the GSFC area, in June 2003.
- 1016 The Contractor shall prepare and submit a PLASTIC Instrument Pre-ship Review (IPSR) Data Package.

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**STATEMENT OF WORK FOR PLASTIC FOR STEREO PHASE B/C/D/E**

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- 1017 The Contractor shall present the PLASTIC IPSR Data Package to the GSFC Code 301 Systems Review team in the UNH area, in October 2003.
- 1018 The Contractor shall prepare and submit a PLASTIC Pre-ship Review (PSR) Data Package, which will be incorporated in the STEREO Observatory PSR data package.
- 1019 The Contractor shall present the PLASTIC PSR Data Package to the GSFC Code 301 Systems Review team in a location local to the GSFC area, in February 2004.
- 1020 The Contractor shall provide program schedule and progress information, updated monthly.
- 1021 The Contractor shall prepare and submit PLASTIC inputs to JHU/APL for the STEREO Safety Implementation Plan, Mission Operations Plans, Electro-magnetic Compatibility Plan, Contamination Control Plan, Integration and Test Plan, Observatory Failure Modes and Effects Analysis, Observatory Fault Tree Analysis and Observatory Verification Matrix.
- 1022 The Contractor shall prepare and submit to the COTR for approval, a PLASTIC Product Assurance Implementation Plan (PLASTIC PAIP). Once the COTR has approved the plan, the Contractor shall implement the PAIP and it shall be the controlling assurance management document.
- 1023 The Contractor shall prepare and submit to the COTR for approval a Configuration Management Plan. Once the COTR has approved the plan, the Contractor shall implement it and it shall be the controlling configuration management document.
- 1024 The Contractor shall provide documentary photographs of the PLASTIC Instrument at various stages of assembly.
- 1025 The Contractor shall prepare and submit a Final Report. The report shall include:
- 1) A brief chronological history of the development of the instrument, including synopses of major project reviews beginning with PDR.
  - 2) A synopsis of instrument science objectives and instrument performance requirements with a synopsis of the actual achievements of the instrument.

**2000 SYSTEM ENGINEERING**



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**STATEMENT OF WORK FOR PLASTIC FOR STEREO PHASE B/C/D/E**

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- 2001 The Contractor shall prepare and deliver a PLASTIC Performance Specification that defines the performance characteristics of the PLASTIC instrument such as field of view, linearity, resolution, bandwidth. Verification of the performance requirements shall be included as a section in the PLASTIC Performance Specification. A Performance Verification Matrix shall be included to demonstrate compliance with all salient Performance Specification Requirements.
- 2002 The Contractor shall design the PLASTIC Instrument and its GSE in accordance with the PLASTIC Performance Specification, *PLASTIC Product Assurance Implementation Plan*, *STEREO Environments Definition, Observatory, Component and Instrument Test Requirements Document*, and the *STEREO Mission Requirements Document*.
- 2003 The Contractor shall develop, provide configuration management, and make available to the COTR, Engineering Layout Drawings of the PLASTIC Instrument. The drawings shall meet the intent of DOD-D-1000 Level 1, namely, Engineering Drawings and associated lists prepared to this Level shall, as a minimum, disclose engineering design information sufficient to evaluate an engineering concept and may provide information sufficient to fabricate developmental hardware. Engineering drawings and associated lists prepared to this Level shall be legible and include those types amenable to the mode of presentation. Layout drawings and combinations of types of engineering drawings may be used to convey the engineering concept in such a manner that the engineering information is understandable to cognizant Government engineers and scientists and enable fabrication by the design contractor of developmental hardware for test or experimentation.”
- 2004 The Contractor shall develop, provide configuration management, and make available to the COTR, Electrical Schematic Drawings of the PLASTIC Instrument. Schematics shall include, but not be limited to subassemblies, boxes, internal wiring, timing diagrams. NASA will use this documentation for detailed review of systems hardware, circuitry and functions. The drawings shall meet the intent of DOD-D-1000 Level 1, as explained above in 2003
- 2005 The Contractor shall develop a PLASTIC Thermal Analytical Model of the PLASTIC Instrument. The Contractor shall document these models in a written report that shall be submitted to the COTR. These models shall be provided to JHU/APL for inclusion in the observatory-level thermal and structural models.
- 2006 The Contractor shall develop Failure Modes and Effects Analysis for the PLASTIC Instrument at the interface between the instrument and the spacecraft

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**STATEMENT OF WORK FOR PLASTIC FOR STEREO PHASE B/C/D/E**

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and submit this analysis in a report to the COTR as specified in the *PLASTIC Product Assurance Implementation Plan*.

- 2007 The Contractor shall provide technical support for mission design, PLASTIC Instrument and spacecraft interface, and for PLASTIC Instrument spacecraft integration and test. The technical support shall include but not be limited to science experiment design, interface design assistance and instrument repair and calibration..
- 2008 The Contractor shall formulate and write the PLASTIC Environmental Test Plan. The plan shall define the tests and analyses that collectively demonstrate that the hardware and software comply with the *PLASTIC Product Assurance Implementation Plan*. The PLASTIC Environmental Test Plan shall show the overall approach to accomplish the experiment qualification and acceptance program.
- 2009 The Contractor shall formulate and write the PLASTIC Verification Matrix. The PLASTIC Verification Matrix shall summarize all the tests that will be performed on each experiment unit. The purpose of the matrix is to provide a ready reference to the contents of the test program and to provide traceability of the qualification heritage of the hardware. All flight hardware spares and prototypes (when appropriate) shall be included in the matrix.
- 2010 The Contractor shall provide inputs to JHU/APL to update the PLASTIC Interface Control Document.
- 2011 The Contractor shall provide a detailed physical block diagram of the PLASTIC Instrument. In addition, a grounding diagram of the PLASTIC instrument shall be produced. The grounding diagram shall include all PLASTIC subsystems.
- 2012 The contractor shall support the development of reliability block diagrams (RBDs) and a probabilistic risk assessment (PRA) by NASA.

**3000 HARDWARE**

- 3001 The Contractor shall fabricate all flight or flight-interfacing hardware in accordance with the NASA approved PLASTIC Product Assurance Implementation Plan, The Plasma and Suprathermal Ion and Composition (PLASTIC) Phase A Concept Study Report, the NASA approved PLASTIC Performance Specification, the STEREO EMI/EMC Control Plan, STEREO Contamination Control Plan, and the STEREO Environments Definition, Observatory, Component and Instrument Test Requirements Document.

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**STATEMENT OF WORK FOR PLASTIC FOR STEREO PHASE B/C/D/E**

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- 3002 The Contractor shall fabricate and deliver the PLASTIC Proto-flight Model Instrument.
- 3003 The Contractor shall fabricate and deliver a second PLASTIC Proto-flight or one PLASTIC Flight Model Instrument.
- 3004 The Contractor shall fabricate PLASTIC spare parts as deemed necessary by PLASTIC for repair and maintenance of the PLASTIC instrument and support hardware.
- 3005 The contractor shall furnish the COTR with a Preliminary and Final Parts Identification List. The Parts Identification List shall include all parts used (or going to be used) during fabrication of the PLASTIC instrument. All changes to the Preliminary Parts list shall be reported to the project monthly.
- 3006 The contractor shall furnish the COTR with a Preliminary and Final Hazardous Materials List. The Hazardous Materials List shall include all hazardous materials used (or to be used) during fabrication, integration and testing of the PLASTIC instrument including at the spacecraft integrator and the launch site. All changes to the Preliminary Hazardous Materials list shall be reported to the project monthly.
- 3007 The contractor shall furnish NASA with a Preliminary and Final Materials and Processes List. The Materials and Processes List shall include all materials and processes used (or to be used) in the PLASTIC instrument. All changes to the Preliminary Materials list shall be reported to the project monthly.
- 3008 Printed Wiring Board Coupons shall be submitted to NASA for all printed wiring boards used within the PLASTIC instrument.
- 3009 The following resources shall be within 15% of the actual spacecraft resources utilized.

Mass: 11.6 Kg  
Power: 8.8W (Average)  
Power: 10.7 W (Peak)  
Data Rate: 2000 bps

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**STATEMENT OF WORK FOR PLASTIC FOR STEREO PHASE B/C/D/E**

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**4000 SOFTWARE**

- 4001 The Contractor shall formulate, write and submit a PLASTIC Instrument Ground Software Development and Management Plan that shall meet the requirements of the NASA approved *PLASTIC Product Assurance Implementation Plan*. This plan shall include appropriate internal software review such as Software Requirements Review (SRR), Test Readiness Review (TRR), and Software Acceptance Review (SAR) at the contractors facility.
- 4002 Once the PLASTIC Instrument Ground Software Development and Management Plan has been approved by NASA, the Contractor shall design, code, debug and verify all ground software required for the PLASTIC Investigation in accordance with the PLASTIC Instrument Ground Software Development and Management Plan and the NASA approved *PLASTIC Product Assurance Implementation Plan*.

**5000 GROUND SUPPORT EQUIPMENT (GSE)**

- 5001 The Contractor shall provide Mechanical Ground Support Equipment (MGSE) for the handling of the instruments during instrument build-up and test, shipping, and installation operations at the spacecraft contractor. The MGSE shall meet the requirements for MGSE contained in the NASA approved *PLASTIC Product Assurance Implementation Plan*.
- 5002 The Contractor shall provide Electrical Ground Support Equipment (EGSE) for the control and operation of the instruments during instrument build-up and test, performance evaluation, test, simulation and stimulation of the flight instruments. The EGSE shall meet the requirements for EGSE contained in the NASA approved PLASTIC Product Assurance Implementation Plan.

**6000 ASSEMBLY, INTEGRATION AND VERIFICATION (AIV)**

- 6001 The Contractor shall provide all supervision, labor, equipment, parts and supplies to support the PLASTIC instruments (two) AIV. The PLASTIC instruments (two) AIV shall be performed in accordance with the PLASTIC Verification Plan, the PLASTIC Product Assurance Implementation Plan, the STEREO EMI/EMC Control Plan, and the STEREO Contamination Control Plan.
- 6002 The Contractor shall provide a PLASTIC Acceptance Data Package for each Proto-Flight and/or Flight Model. The Acceptance Data Package shall include:
- 1) Identification of actual build status and an assessment of the potential differences to the design qualification baseline.

**STATEMENT OF WORK FOR PLASTIC FOR STEREO PHASE B/C/D/E**

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- 2) Evaluation of test and inspection results necessary for verification of applicable specification and interface requirements.
- 3) Applicable Non-Conformance Reports and Waiver Requests.
- 4) Acceptability of Residual Hazards.
- 5) Historical Records, Limited Life Item Records, Open Work Records, Temporary Installation Records, Travelers, copies of relevant Log Book pages, or equivalent documentation.

6003 The Contractor shall provide at JHU/APL all supervision, labor, equipment, parts and PLASTIC supplies (except GN2) to support the STEREO Spacecraft (two) AIV.

6004 The Contractor shall prepare and submit to NASA for approval by the COTR, a PLASTIC Instrument to Spacecraft Integration Procedure.

**7000 DATA PROCESSING**

7001 The Contractor shall develop, submit to the COTR for approval, and implement the approved PLASTIC Plan for Data Processing. This plan shall address the various team responsibilities; what data products are produced and their description; and how the data is obtained, processed, archived, and distributed.

**8000 SPECIAL TASKS**

8001 The Contractor shall provide technical support, maintenance, repair and recalibration of the PLASTIC Instruments. This shall include support during integration and test of the two flight instruments, and during launch operations at the launch site and on-orbit checkout of the PLASTIC Instruments after launch.

8002 The Contractor shall store and make retrievable all PLASTIC related documentation and hardware for the duration of the mission.

**9000 SCIENCE**

9001 The Contractor shall attend the STEREO Science Working Group (SWG).

9002 PLASTIC Solar Wind Sector (SWS) shall provide solar wind proton density, velocity, and kinetic temperature with a few minutes time resolution and solar wind elemental and charge state abundance ratios for key species (H<sup>+</sup>, He<sup>+2</sup>, O<sup>+6</sup>, O<sup>+7</sup>, Fe<sup>+7</sup> through Fe<sup>+16</sup>) with several minutes resolution, under most solar wind conditions.

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**STATEMENT OF WORK FOR PLASTIC FOR STEREO PHASE B/C/D/E**

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- 9003 To meet these science measurement requirements, the PLASTIC SWS shall be able to measure ions in the energy per charge (E/Q) range 0.5 to 80 keV/e. Protons (H+) with  $E/Q < 7.5$  keV/e shall have a polar field of view of 30 degrees (+/-15 degrees) and an azimuthal field of view of 40 degrees (+/-20 degrees from sun-direction). PLASTIC SWS shall have a M/Q range of 1 to 20 amu/e and a mass range of 1 to 60 amu. PLASTIC SWS shall distinguish selected major solar wind species (H+, He+2, O+6, O+7, and Fe+7 to Fe+16) in the E/Q range 30 to 80 keV/e.
- 9004 The PLASTIC Wide Angle Partition (WAP) shall measure the mass per charge (M/Q) in the range 1 to 20 amu/e and provide distribution functions for suprathermal ions up to 80 keV/e with several minutes time resolution.

**10000 MISSION OPERATIONS AND DATA ANALYSIS**

- 10001 The Contractor shall develop a PLASTIC Experiment Users Manual for flight operations. The information in this manual shall include:
- 1) Experiment Interfaces (Mechanical, Electrical, Optical, Data, Block Diagrams, etc.)
  - 2) Nominal Operations
  - 3) Contingency Operations
  - 4) Identification of In-Flight Hazardous Operations
- 10002 The Contractor shall provide technical support for the PLASTIC Instruments during the mission operations phase of the project as required by NASA for a period of launch plus orbit insertion plus commissioning and mission life.
- 10003 The Contractor shall be responsible for the reduction, analyses, interpretation of the data, and publication of scientific results obtained by the PLASTIC Instruments for a period of commissioning and mission life.
- 10004 The contractor shall establish an Education/Public Outreach (EPO) program. That program shall have the following components:
- Development of self guided, web-based lesson modules.
  - Teacher workshops and dissemination of resources through and existing national network of science museums.